Technology and implementation of electric vehicles and plugin hybrid electric vehicles

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Appendix a

- Technology and implementation of electric vehicles and plug-in hybrid electric vehicles

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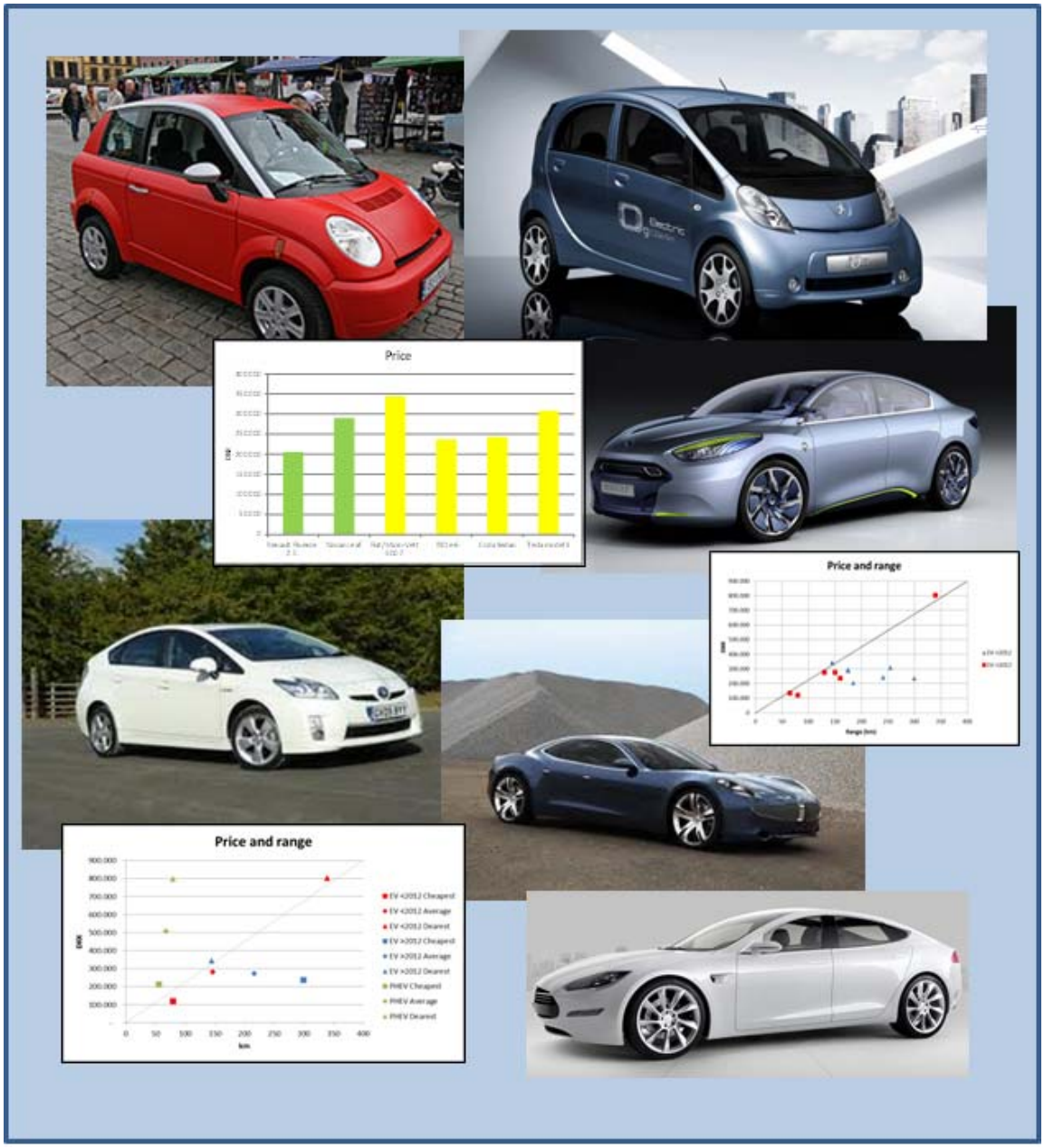

Contents

1. Vehicle models

The specifications for each vehicle model are listed below for EVs <2012 and EVs >2012, electric vans, electric trucks, PHEVs and HEVs.

2. Electric Cars

A number of electric vehicles are currently available on the market or will be in the near future. Some of these are presented in the next chapter to give a brief review of the current technology available. The models outlined in this section are expected to be the ones with the highest market potential in Denmark and Europe.

It is important to note, that the reliability of price data varies from model to model and has thus been rated strong if Danish distributors have prices available (green color in graphs), medium if currency exchange rates have been used (orange color in graphs) or low if the sources are expected prices or adjusted to enable comparisons (yellow color in graphs). The investment prices apply for the Danish market unless otherwise is noted.

The driving range in the specifications may vary according to driving patterns, weather-, temperature- and road conditions, car age, equipment and state of maintenance. Driving range tests can be performed according to NEDC (New European Driving Cycle) based on the EU-directive ECE R101 dealing with measurement of the emission of carbon dioxide and fuel consumption.

2.1. EVs <2012

The first three models, Mitsubishi iMiEV, Peugeot iOn and Citroen C-Zero are the first mass-produced EVs in Denmark, while the other models only or sold in smaller amounts or are conversions of ICE models. The investment price is gathered from a Danish distributor. Price data = strong reliability.

2.1.1. Mitsubishi iMiEV

Specifications:

Type		All electric
No. of seats		4
Price (incl. VAT)	DKK	275,995
Engine power	kW	49
Torque	Nm	180
Energy consumption	Wh/km	135*
Top speed	Km/h	130
Range	Km	150*
Total weight	Kg	1450
Length	mm	3475
Battery	V	330 Lithium-ion
Charge time (220 V)	Hours	6
Electrical energy storage	kWh	16

*NEDC

Source: Mitsubishi.dk

2.1.2. Peugeot iOn

Peugeot iOn is a sister model to the Mitsubishi iMiEV. The investment price is from a Danish distributor. Price data = strong reliability.

Source: peugeot.dk

Specifications:

Type		All electric
No. of seats		4
Price (incl. VAT)	DKK	274,990
Engine power	kW	47
Torque	Nm	180
Energy consumption	Wh/km	-
Top speed	Km/h	130
Range	Km	150
Total weight	Kg	1450
Length	mm	3480
Battery	V	330 Lithium-ion
Charge time (220V – 16A)	Hours	6
Electrical energy storage	kWh	16

2.1.3. Citroën C-Zero

Citroën C-Zero is a sister model to the Peugeot iOn and Mitsubishi iMiEV. The investment price is from a Danish distributor. Price data = strong reliability.

Specifications:

Type		All electric
No. of seats		4
Price (incl. VAT)	DKK	275,615
Engine power	kW	49
Torque	Nm	180
Energy consumption	Wh/km	135
Top speed	Km/h	130
Range	Km	150*
Total weight	Kg	1450
Length	mm	3480
Battery	V	330 Lithium-ion
Charge time (220 V)	Hours	8
Electrical energy storage	kWh	16

Source: citroen.dk

*according to EU-cycle

2.1.4. Tesla Roadster

The Tesla Roadster is a sports car with only two seats. The investment price is from a Danish distributor. Price data = strong reliability.


Source: teslamotors.com

Specifications:

Type		All electric
No. of seats		2
Price (incl. VAT)	DKK	803,000
Engine power	kW	215
Torque	Nm	273
Energy consumption	Wh/km	188
Top speed	Km/h	201
Range	Km	340*
Total weight	Kg	1240
Length	mm	3939
Battery	V	Lithium-ion
Charge time (240V – 70 amps)	Hours	3,5
Electrical energy storage	kWh	53

*based on European Electric Vehicle Combined Cycle

2.1.5. Kewet Buddy Basic

This electric vehicle is developed by a Norwegian manufacturer and is mainly for urban driving. The model is available with two different battery technologies that affects price, range, charge time and energy storage capacity. The company produces around 1,000 cars every year and 2,000 are already on the Norwegian roads (ElFORSK et al. 2010). The price is estimated by converting from Norwegian to Danish currency with no other changes, as the VAT is unchanged. Price data = medium reliability.

Specifications:

Type		All electric
No. of seats		3
Price (incl. VAT)	NOK/(DKK)	124,900/169,900 (120,366/ 163,732)*
Engine power	kW	13
Torque	Nm	-
Energy consumption	Wh/km	-
Top speed	Km/h	80
Range	Km	80/120
Total weight	Kg	1090/995
Length	mm	2430
Battery	V	ALB (lead 72V)/BAES (Nickel metal hydride 72V)
Charge time (220 V)	Hours	6-8/8-10
Electrical energy storage	Ah	182/200

* 1 DKK = 0.9637 NOK

Source: puremobility.com

2.1.6. Think City

Think City is being produced by Norwegian Think Global and Partner Valmet Automotive and is used by MoveAbout etc. This model is primarily for urban driving and is categorized as one of the smaller EVs. The investment price is based on articles and web sites. Price data = low reliability.


Source: Wikipedia.org

Specifications:

Type		All electric
No. of seats		2
Price (incl. VAT)	NOK/(DKK)	244,000 (235142)*
Engine power	kW	34
Torque	Nm	-
Energy consumption	Wh/km	-
Top speed	Km/h	110
Range	Km	160
Total weight	Kg	1038
Length	mm	3143
Battery	V	Lithium-ion/liquid sodium
Charge time (230V)	Hours	9-10
Electrical energy storage	kWh	23/24

* 1 DKK = 0.9637 NOK

2.1.7. Mega City

The French EV manufacturer Mega-vehicles produces the model called Mega City, which is a small car primarily for urban driving with a top speed of 64 km/h. The price is based on articles. Price data = low reliability.

Specifications:

Type		All electric
No. of seats		4
Price (incl. VAT)	DKK	134,596
Engine power	kW	13
Torque	Nm	-
Energy consumption	Wh/km	-
Top speed	Km/h	64
Range	Km	65
Total weight	Kg	1025
Length	mm	2959
Battery	V	AGM lead
Charge time (230V – 16A)	Hours	8
Electrical energy storage	kWh	10


Source: mega-vehicles.com

2.1.8. REVA

The Indian car manufacturer Mahindra REVA produces the EV model REVA. The company has sold more than 4,000 REVA's worldwide in 24 different countries. It is a relatively small car with low top speed and range. The price data is collected from a Danish distributor. Price data = strong reliability.

Source: petrolfreeworld.com

Specifications:

Type		All electric
No. of seats		4
Price (incl. VAT)	DKK	118,000
Engine power	kW	13
Torque	Nm	52
Energy consumption	Wh/km	-
Top speed	Km/h	80
Range	Km	80
Total weight	Kg	-
Length	mm	2638
Battery	V	48, lead acid
Charge time (220V – 15A)	Hours	8
Electrical energy storage	Ah	200

2.2. EVs >2012

These models will be available within the coming years.

2.2.1. Nissan Leaf

This car is on sale from November 2011 in Scandinavia and was awarded Car of the year 2011 in Europe. Price data is from a Danish distributor. Price data = strong reliability.

Source: Nissan.dk, autonorden.dk

*NEDC

Specifications:

Type		All electric
No. of seats		5
Price (incl. VAT)	DKK	290,690
Engine power	kW	80
Torque	Nm	280
Energy consumption	Wh/km	-
Top speed	Km/h	145
Range	Km	175*
Total weight	Kg	-
Length	mm	4445
Battery	V	Lithium-ion
Charge time (220 V)	Hours	7
Electrical energy storage	kWh	24

2.2.2. Coda Sedan

The Coda Sedan is the first car developed by the American producer Coda. The market launch of the car has been rescheduled several times, but is now expected to be in late 2011 and initially only in California. The Coda Sedan has a longer range than most EV models. The price data is based on the expected American investment cost and then converted to DKK (*1 USD = 5.42 DKK). Price data = low reliability.

Specifications:

Type		All electric
No. of seats		5
Price (incl. VAT)	USD/(DKK)	44,900 (243,358)*
Engine power	kW	100
Torque	Nm	300
Energy consumption	Wh/km	-
Top speed	Km/h	137
Range	Km	241
Total weight	Kg	1240
Length	mm	4481
Battery	V	Lithium iron phosphate 333
Charge time (220V – 30 amps)	Hours	6
Electrical energy storage	kWh	36

Source: codaautomotive.com

2.2.3. Renault Fluence Z.E.

Renault is launching a series of electric cars in the beginning of 2012, including the Renault Fluence Z.E that is expected to have a lower price than competing electric cars. The first countries for the launch are in Denmark and Israel. It will be possible to lease this car in a BetterPlace subscription for 1,495 DKK/month incl. VAT in Denmark. Price data stems from a Danish distributor. Price data = strong reliability.

Source: Renault.com, (Stockholm Municipality and Vattenfall AB 2011), bilia.dk

Specifications:

Type		All electric
No. of seats		5
Price (incl. VAT)	DKK	205,000
Engine power	kW	70
Torque	Nm	226
Energy consumption	Wh/km	170
Top speed	Km/h	135
Range	Km	185*
Total weight	Kg	1543
Length	mm	4748
Battery	V	Lithium-ion
Charge time (220 V)	Hours	6-8
Electrical energy storage	kWh	22

*NEDC

2.2.4. NICE/Fiat Micro-Vett 500

Fiat and NICE have in partnership converted some of the Fiat models to electric driving. Besides the Fiat 500 other converted models are Fiat Doblò and Fiat Fiorino Cargo Electric. This model is expected to be presented in late 2011. Price data is collected based on different articles. Price data = low reliability.

Specifications:

Type		All electric
No. of seats		4
Price (incl. VAT)	DKK	344,000
Engine power	kW	30
Torque	Nm	-
Energy consumption	Wh/km	160
Top speed	Km/h	105
Range	Km	145
Total weight	Kg	1062
Length	mm	3546
Battery	V	Lithium-ion
Charge time (220 V)	Hours	8
Electrical energy storage	kWh	22

Source: danskelbilkomite.dk

2.2.5. BYD e6

The Chinese high-tech company BYD (Build your dreams) is one of the world's leading comapnies in battery technologies, new energy etc. The range of this model is one of the longest for an electric vehicle caused by the new battery technology. Furthermore the battery is expected to have 6,000 cycles life, which is more than most batteries today. The company expects to launch some of their BYD e6 models in the United States in the second quarter of 2012. The price is before any governmental incentives. The data for this model has been announced by the company itself and has not been tested by any other parties. It is planned to be launched in a more powerful version on the American market. The data is a little uncertain is modifications to the given values have been done several times already. Price data is based on articles and is added costs according to Danish VAT. Price data = low reliability.

Source: byd.com

Specifications:

Type		All electric
No. of seats		5
Price (incl. VAT)	USD/(DKK)	43,750 (237125 DKK)*
Engine power	kW	75
Torque	Nm	450
Energy consumption	Wh/km	207
Top speed	Km/h	140
Range	Km	300
Total weight	Kg	1822
Length	mm	4560
Battery	V	Iron-Phosphate
Charge time (220 V)	Hours	6
Electrical energy storage	kWh	48

* 1 USD = 5.42 DKK

2.2.6. Tesla model S

The Tesla Model S is still under development and production for Europe is scheduled to begin in late 2012 or early 2013. Battery upgrades to increase the driving range to 370 km (+ USD 10,000, 65 kWh) and 480 km (+USD 20,000, 85 kWh) are optional. Final features and prices etc. are under development and will first be announced when finalized. The investment prices are based on the expected American price and may increase when imported to Europe. Price data = low reliability.

Specifications:

Type		All electric
No. of seats		7
Price (incl. VAT)	USD/(DKK)	57,000 (308,940 DKK)*
Engine power	kW	-
Torque	Nm	-
Energy consumption	Wh/km	188
Top speed	Km/h	193
Range	Km	255
Total weight	Kg	1735
Length	mm	4973
Battery	V	Lithium-ion
Charge time (230 V)	Hours	-
Electrical energy storage	kWh	42

*1 USD = 5.42 DKK

Source: teslamotors.com

2.2.7. Other electric cars under development

Toyota FT-EV (2012), Renault Twizy Z.E. (2012), Renault ZOÉ Z.E. (2012), BMW Megacity (2013), Koenigsegg (the sports car will get a driving range above 500 km and the charging time will be as low as 20 min.), etc., are currently under development. A new type of minibus Vantage/Avancee Minibus will be available within short time as well as light truck from VantageAvancee (2012).

3. Electric Vans

Some electric vans are also on sale or will be in the near term.

3.1.1. Peugeot Partner Van

This van is available on the Danish market and is one of the first 100% electric vans. The price is based on data from a Danish distributor. Price data = strong reliability.

Specifications:

Type		All electric
No. of seats		2
Price (incl. VAT)	DKK	300,000
Engine power	kW	42
Torque	Nm	180
Energy consumption	Wh/km	210
Top speed	Km/h	112
Range	Km	120
Total weight	Kg	1890
Length	mm	4137
Load capacity	kg	760
Battery	V	Sodium Nickel Chloride
Charge time (220V – 16A)	Hours	8
Electrical energy storage	kWh	23

Source: Peugeot.dk

3.1.2. Renault Kangoo Z.E.

This van will be available in Denmark in early 2012. The vehicle will be launched with a business model where it is necessary to rent the battery from Renault and a price example is that you have to pay DKK 559/month for three years with a total driving range of 45,000 km. This has been included in the investment price that comes from several articles. Price data = low reliability.

Specifications:

Type		All electric
No. of seats		2
Price (incl. VAT)	EUR/(DKK)	25,000 (186250)*
Engine power	kW	44
Torque	Nm	226
Energy consumption	Wh/km	165
Top speed	Km/h	130
Range	Km	160**
Total weight	Kg	1410
Length	mm	4213
Battery	V	Lithium-ion
Charge time (220 V)	Hours	6-8
Electrical energy storage	kWh	22

* 1 EUR = 7.442 DKK
** NEDC

Source: Renault.dk, (Stockholm Municipality and Vattenfall AB 2011)

4. Electric Trucks

4.1.1. Modec Chassis Cab (Medium)

Also an electric truck is on sale in Denmark, but the majority of the customers are located in the UK (Tesco, UPS, Transport for London etc.). Due to regulations this electric truck avoids paying for congestion charging, road tax and operator tax when driving in UK. Frederiksberg Municipality has purchased three of these trucks in 2011 for use in the Gardening and Road service in the municipality (Frederiksberg Municipality 2011). The truck has a speed limit of 80 km/h and is therefore mainly for driving in cities and urban areas. The price data is derived from a report published by the Danish Transport Authority. Price data = strong reliability.

Specifications:

Type		All electric
No. of seats		2
Price (incl. VAT)	DKK	750,000
Engine power	kW	70
Torque	Nm	300
Energy consumption	Wh/km	-
Top speed	Km/h	80
Range	Km	96/160
Total weight	Kg	5490
Length	mm	5780
Cargo capacity	t	2
Battery	V	Lithium Iron Phosphate/ Sodium Nickel Chloride
Charge time (220 V)	Hours	8
Electrical energy storage	kWh	52/85

Source: modecev.com, (Danish Transport Authority 2010)

4.1.2. Smith Newton

This electric truck was launched in 2006 and is the most sold electric truck to date. The price is based on the data from the American market and has not been adjusted to the Danish conditions. Price data = low reliability.

Source: smithelectric.com

*1 USD = 5.42 DKK

Specifications:

Type		All electric
No. of seats		3
Price (incl. VAT)	USD/(DKK)	150,000 (813,000*)
Engine power	kW	120
Torque	Nm	680
Energy consumption	Wh/km	498
Top speed	Km/h	80
Range	Km	50-240
Total weight	Kg	4728
Length	mm	6795
Battery	V	Lithium-ion
Charge time (220 V)	Hours	8
Electrical energy storage	kWh	120

5. Plug-in Hybrid Electric vehicles

In this category different Plug-in hybrid electric vehicles is outlined, i.e. vehicles that can drive on both electricity and liquid fuels. At the moment few models are on the market.

5.1. Chevrolet Volt 2012

The Chevrolet Volt 2012 is on sale in United States and the price data has not been adjusted to the Danish market and has low reliability.

Source: Chevrolet.com, (Stockholm Municipality and Vattenfall AB 2011)

Specifications:

Type		Plug-in hybrid
No. of seats		4
Price (incl. VAT)	USD/(DKK)	48931 (237125 DKK)*
Engine power	kW	111
Torque	Nm	370
Energy consumption	Wh/km	135
Top speed	Km/h	161
Range (electric)	Km	56
Range (liquid fuel)	km	600
Total weight	Kg	1580
Length	mm	4498
Battery	V	Lithium-ion
Charge time (220 V)	Hours	4
Electrical energy storage	kWh	16

*1 USD = 5.42 DKK

5.2. Fisker Karma

The Fisker Karma model is a luxury sports sedan with focus on speed and power. The company has a Danish division and prices are from a Danish distributor. Price data = strong reliability.

Specifications:

Type		Plug-in hybrid
No. of seats		4
Price (incl. VAT)	DKK	799,000
Engine power	kW	300
Torque	Nm	1300
Energy consumption	Wh/km	-
Top speed	Km/h	200
Range (electric)	Km	80
Range (liquid fuel)	Km	370
Total weight	Kg	-
Length	mm	4998
Battery	V	Lithium-ion
Charge time (220 V)	Hours	-
Electrical energy storage	kWh	20,1

Source: fiskerautomotive.com

6. Hybrid Electric vehicles

A lot of different HEV models are available on the market, but as the focus in this study is on EVs and PHEVs only the most sold model is presented.

6.1. Toyota Prius 1.8 T2

The Toyota Prius 1.8 T2 has the so called Hybrid synergy drive technology, which means that it can either drive on the electric engine, the gas engine or on both at the same time. This is decided by speed, acceleration etc. This allows the electric battery to recharge from braking energy and by using the heat from the exhaust system. This model is available in Denmark and has been sold in large numbers worldwide, especially in Japan. The price data comes from a Danish distributor. Price data = strong reliability.

Source: Toyota.dk

Specifications:

Type		Hybrid
No. of seats		5
Price (incl. VAT)	DKK	389,499
Engine power	kW	100
Torque	Nm	207
Energy consumption	Wh/km	-
Top speed (electric)	Km/h	45
Top speed (liquid fuel)	Km/h	180
Range (electric)	Km	2
Range (liquid fuel)	km	-
Total weight	Kg	1805
Length	mm	4460
Battery	V	Nickel-Metal Hydride 201,6
Charge time (220 V)	Hours	-
Electrical energy storage	kWh	-

7. Comparison of features

A comparison of the different features is listed below to compare the models across vehicle types and technologies.

7.1. Price

An overview of the different investment costs for different EDV models are given below. Is it also possible in Figure 1 to see the reliability of the price data for each vehicle model.

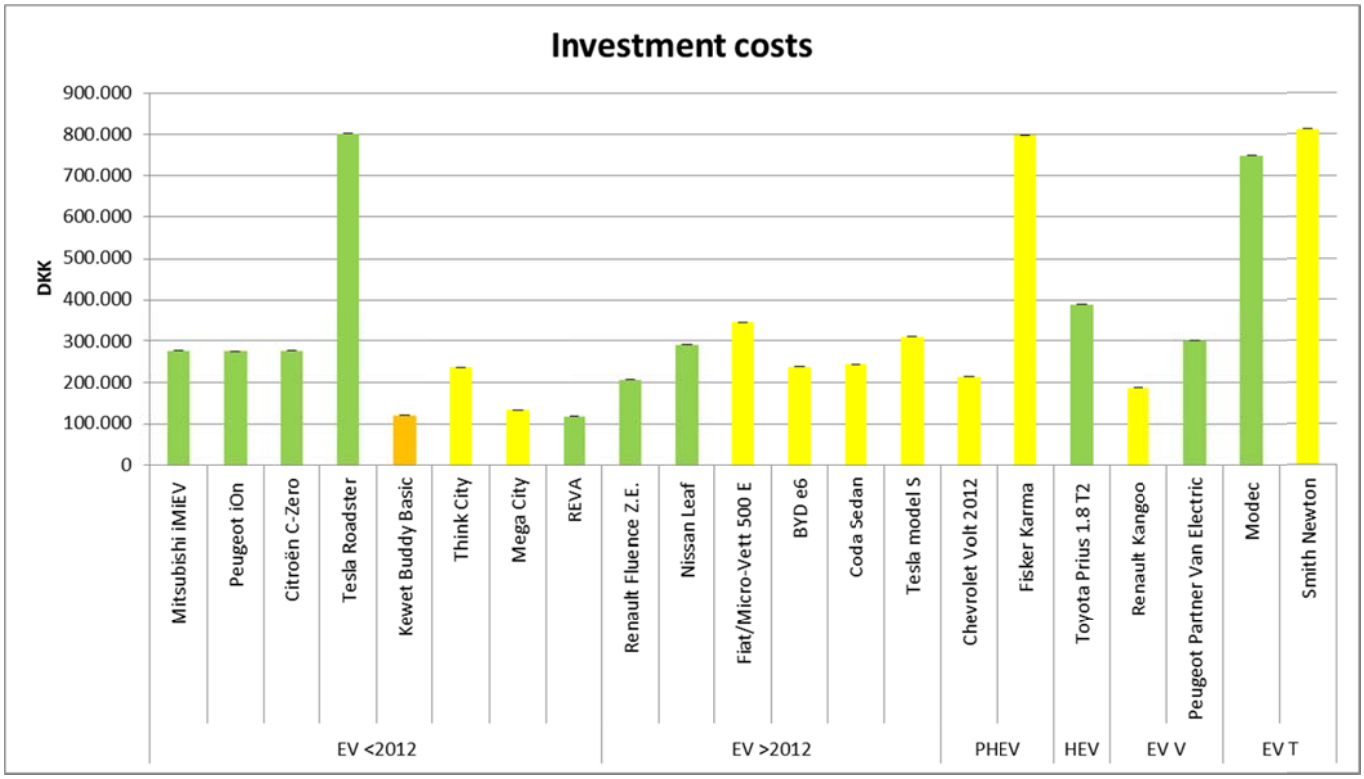

Figure 1: Investment costs for the different models. The pillar colors indicate the price data reliability (green = strong, orange = medium, yellow = low)

From the graph it is evident that the two sports cars Tesla Roadster and Fisker Karma are the models with the highest investment costs of about DKK 800,000. The small urban cars (Kewet, Think City, Mega City, REVA) have costs lower than other models. The remaining EV models have investment costs around DKK 200,000-300,000. The vans are in same price range as most EVs while the truck investment cost is more than DKK 700,000.

7.2. Power capability

The power feature is important in order to obtain long ranges, high top speeds and other performance capabilities.

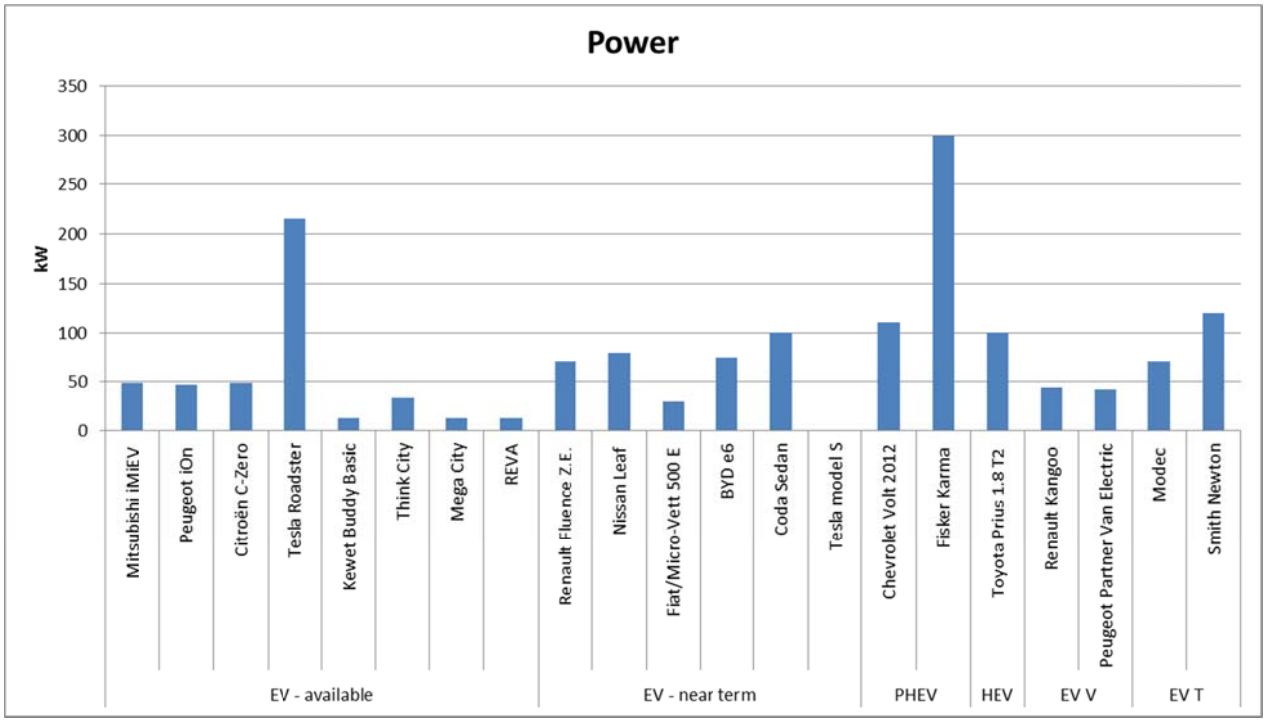

Figure 2: The power capabilities of the different models

The power capabilities of the vehicles vary a lot from around 50-100 for medium sized EVs to around 300 for the sports cars. The small urban cars have the lowest performances below 50 kW, which may affect top speed, range etc.

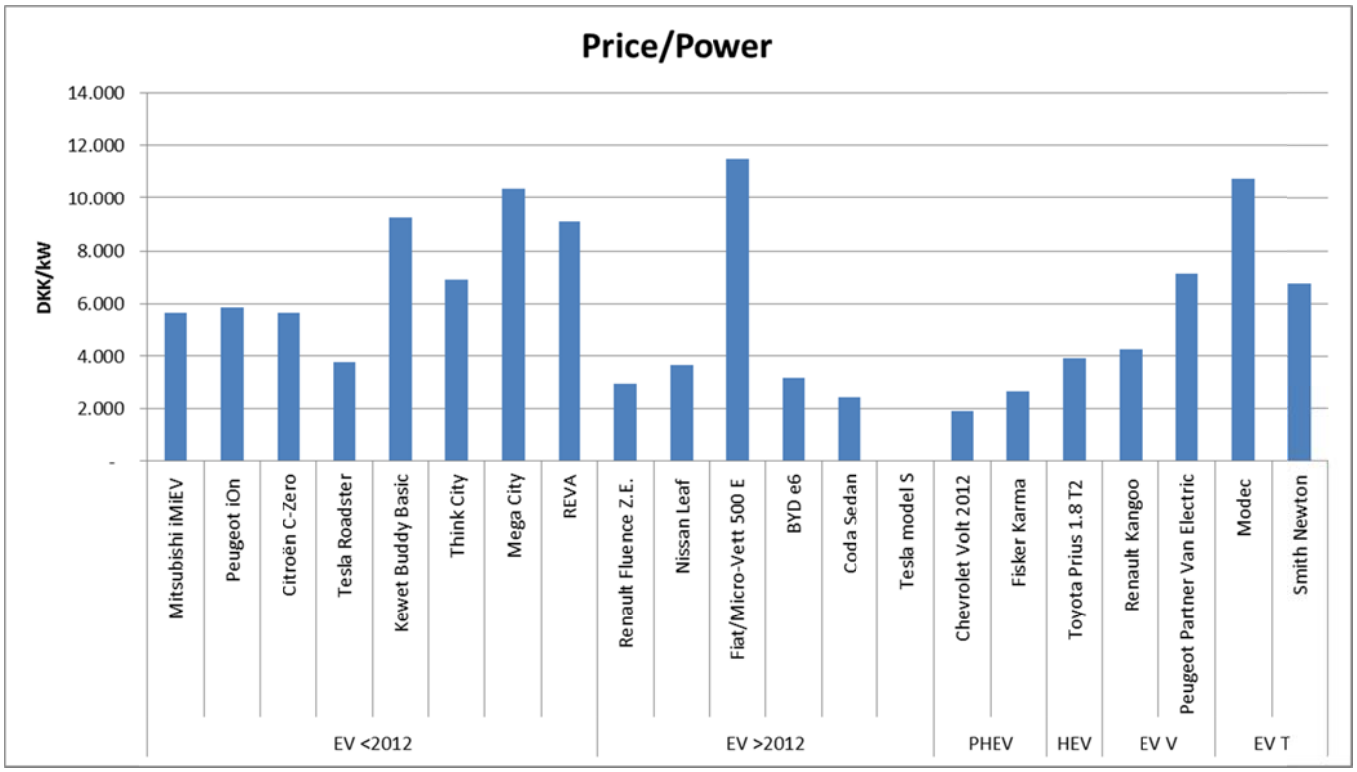

Figure 3: Price compared to power capability

When the power features are compared with the initial investment costs the near term EV technologies have the lowest costs around DKK 2,000-4,000. The small city cars have higher costs above DKK 6,000 per kW while the PHEV and HEV models achieve low costs.

7.3. Energy storage capacity

The energy storage capacity is an important feature if the target is to achieve long electric ranges. The energy storage capacity depends on the technology used in the vehicle and is expected to increase in the near future.

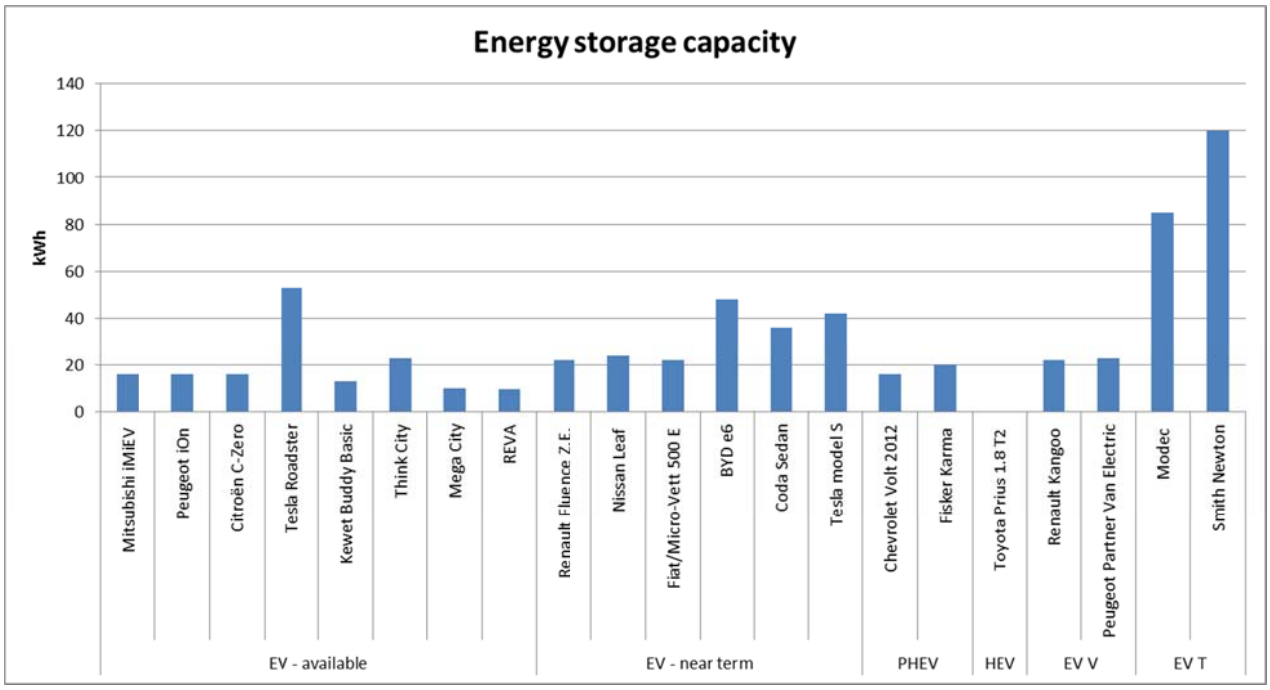

Figure 4: Energy storage capacity for each vehicle

The current available EV models on the market have lower energy storage capacity than the near term models. This is due to new development that may provide more efficient technologies. Especially the BYD e6, Coda Sedan and Tesla model S have high capacities of more than 30 kWh. The PHEVs and HEV do not have the same capacities as the EVs, but are also able to drive using liquid fuel. The sports models have higher storage abilities than the other models. The electric trucks have by far the highest energy storage capacities exceeding 100 kWh.

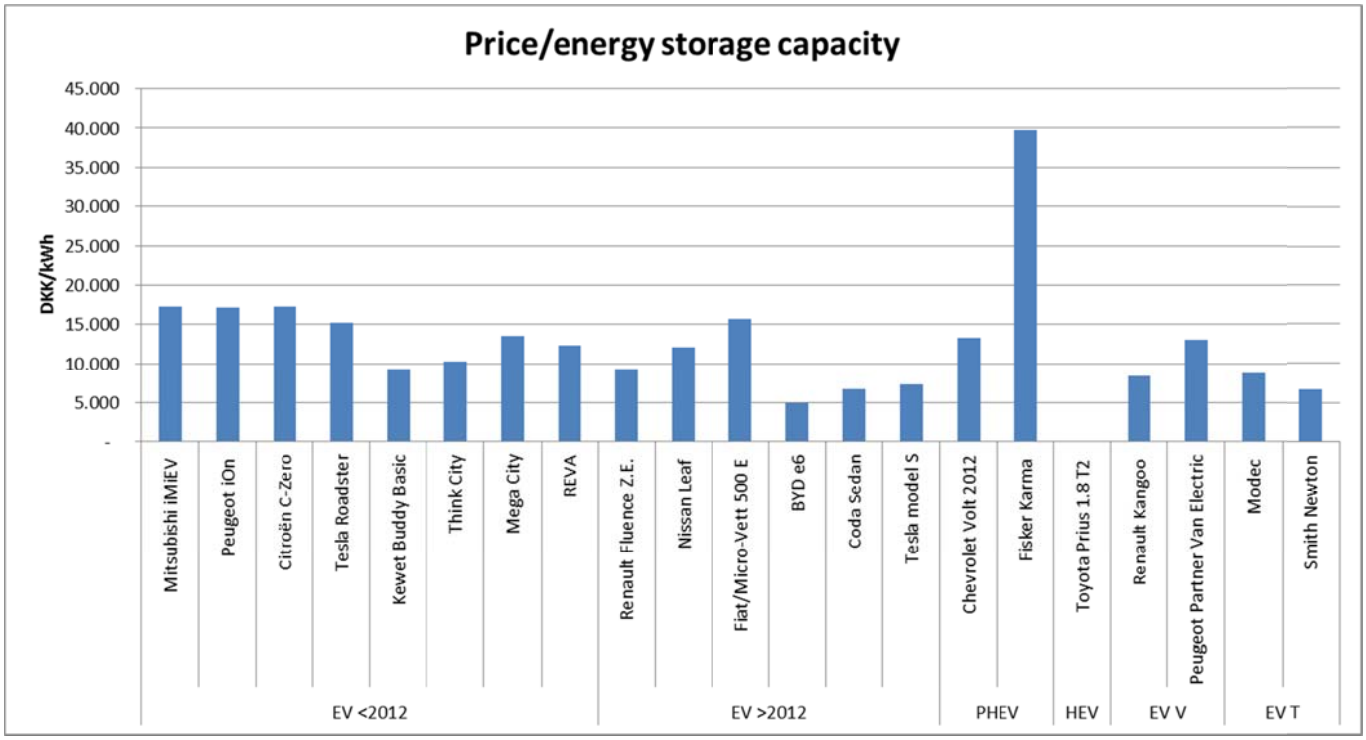

Figure 5: Comparison of the investment cost compared to the energy storage capacity

When comparing the energy storing capacity with the investment cost the near term models have the highest performances with the three earlier mentioned models as the lowest. Their costs are below 8,000 DKK/kWh while current technology models ranges between 10,000 and 17,000 DKK per kWh. When including costs the sports cars are in the same price range as other models. The vans have low costs and also the trucks have lower or same costs as most cars despite the high investment cost around DKK 750,000.

7.4. Range

The electric range is one of the main factors that need to be improved to promote the diffusion of EDVs. The electric range depends on the power performance and the electric storage capacity.

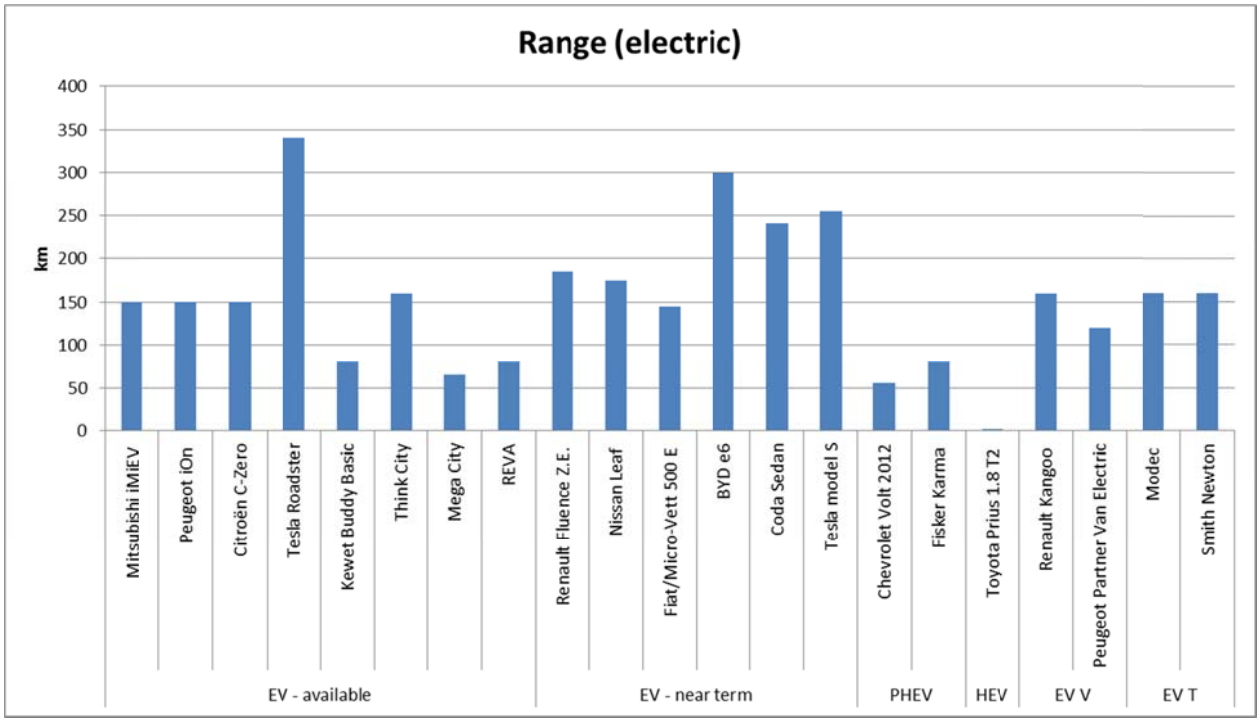

Figure 6: Electric range for the EDVs

The electric range is highest for EVs compared to PHEVs and HEV. The three near term models BYD e6, Coda Sedan and Tesla model S have the longest ranges and are almost able to match the Tesla Roadster range of more than 300 km. The small urban EVs have ranges between 50-80 km and need to charge often if they are to drive long distances. The family car EVs have a range around 150 km per charge. The electric trucks have a range around 150 km and even though the purpose of trucks often is to drive long distances the trucks may be useful for driving in urban areas and large cities.

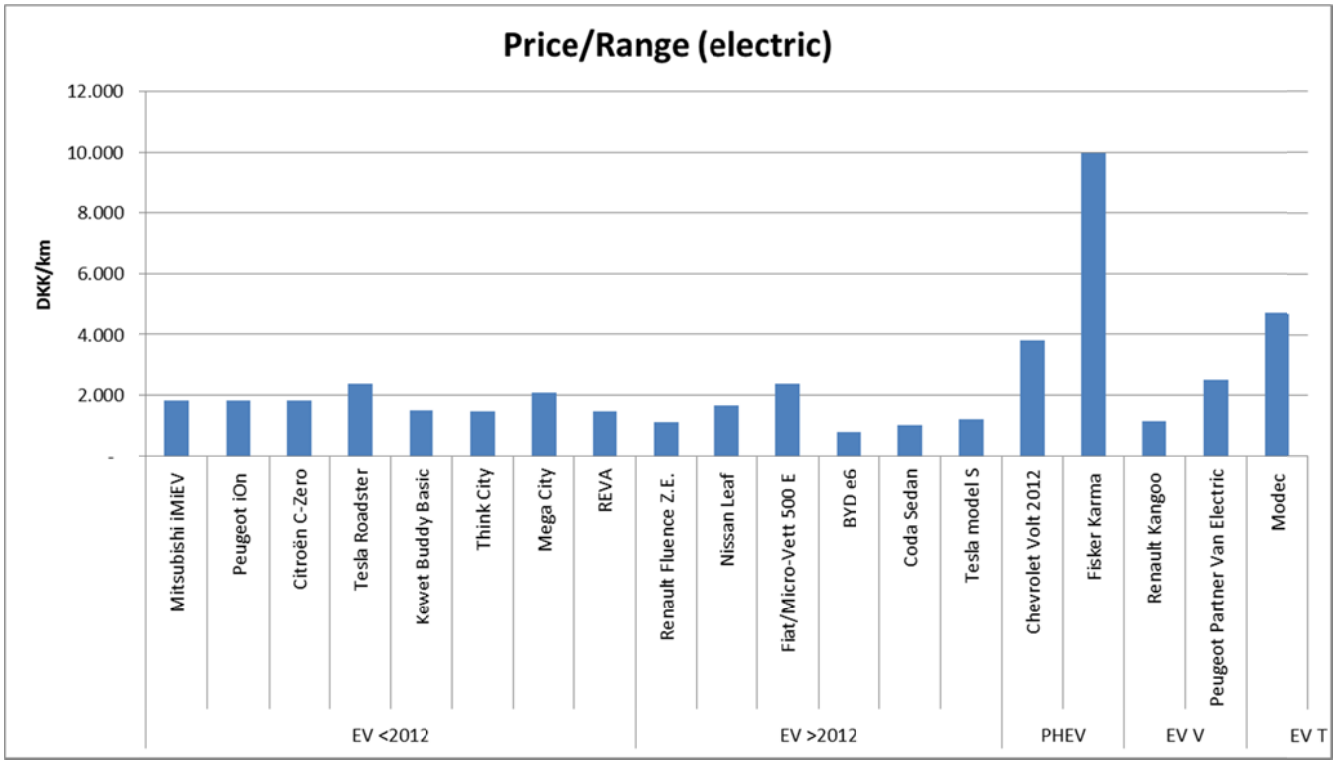

Figure 7: Electric range compared to the investment costs

If the price is included in the assessment of driving ranges most models are in the same price range around 1,600-2,100 DKK/km, but again the BYD e6, Coda Sedan and Tesla model S perform better than other models. The PHEVs are expensive compared to their electric driving range.

7.5. Charge time

A major concern from car users considering purchasing an EDV is often the charge time. The value given below is the slow charge time, which often can be completed privately. Some models also have the ability of quick charging but this is not included in the assessment. The Tesla Roadster has the lowest charge time, but has to be charged using the Tesla High Power Wall Connector at 240 Volts and 70 Amps, which is more powerful than other charge equipment.

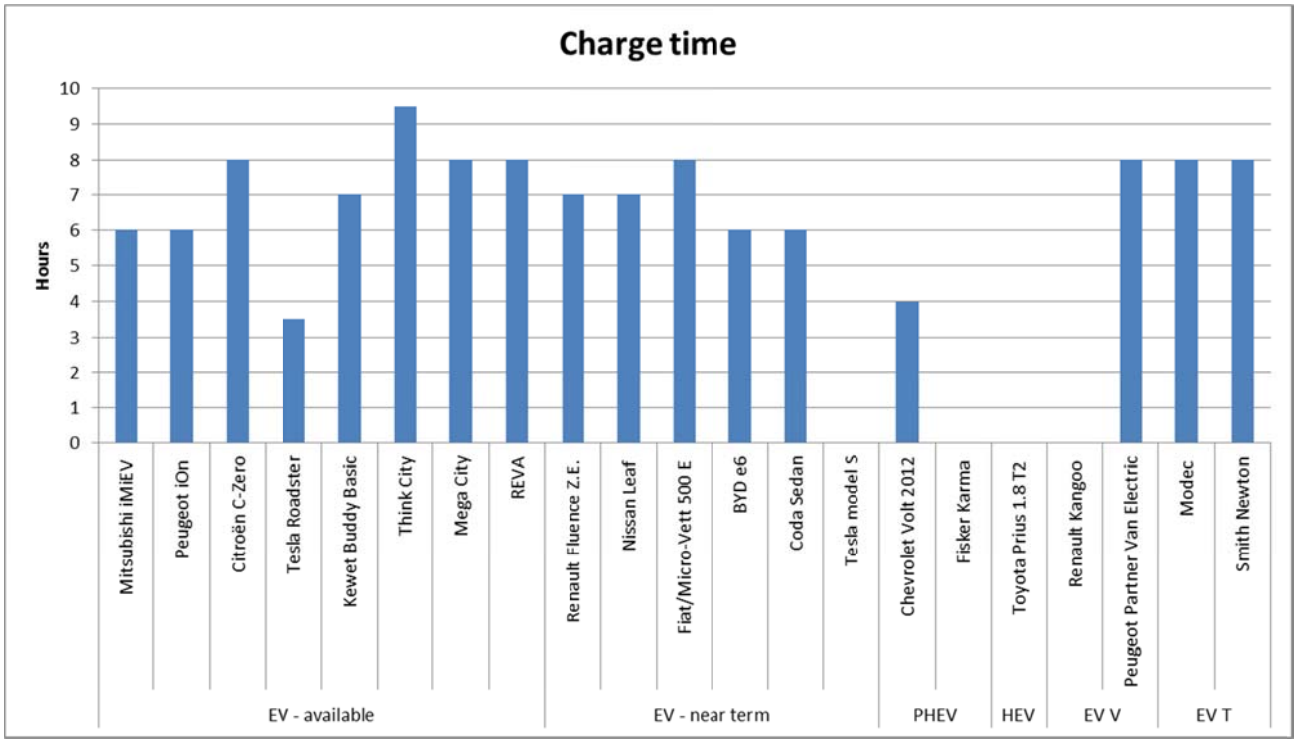

Figure 8: Charge time for each model

The difference in charge time between the models is relatively small and is generally between 6 to 9 hours for EVs. The Tesla Roadster may however charge completely in around 4-5 hours, but with three phases and a higher electric current than other models.

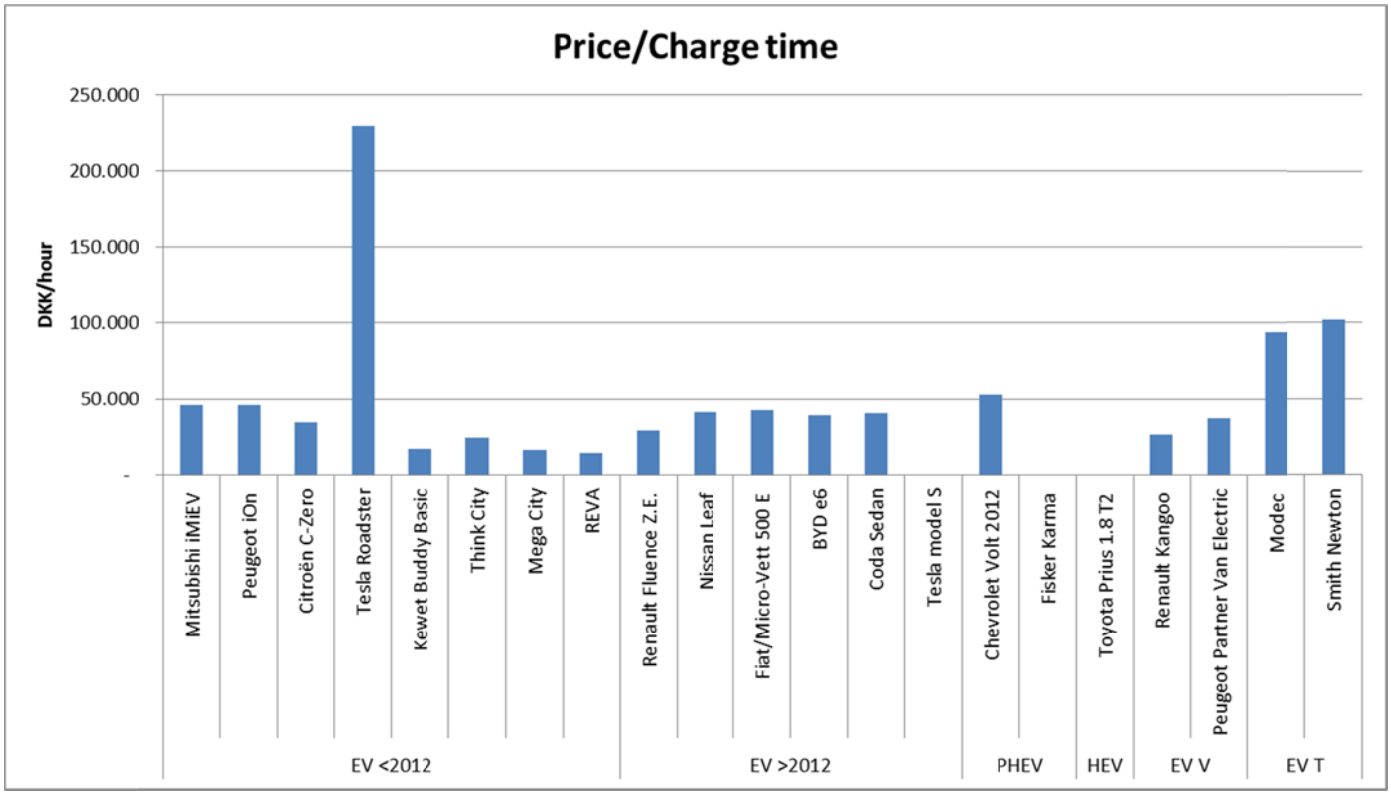

Figure 9: Charge time compared to investment cost

Because of the small differences in charge time the vehicles with the lowest investment costs will also be those with the lowest cost/charge time. The Tesla Roadster has a significant higher cost per charge hour despite having the lowest charge time of all models.

7.6. Energy consumption

The energy consumption measure can give an indication of the vehicles' efficiency and is determined by the battery technology, weight etc.

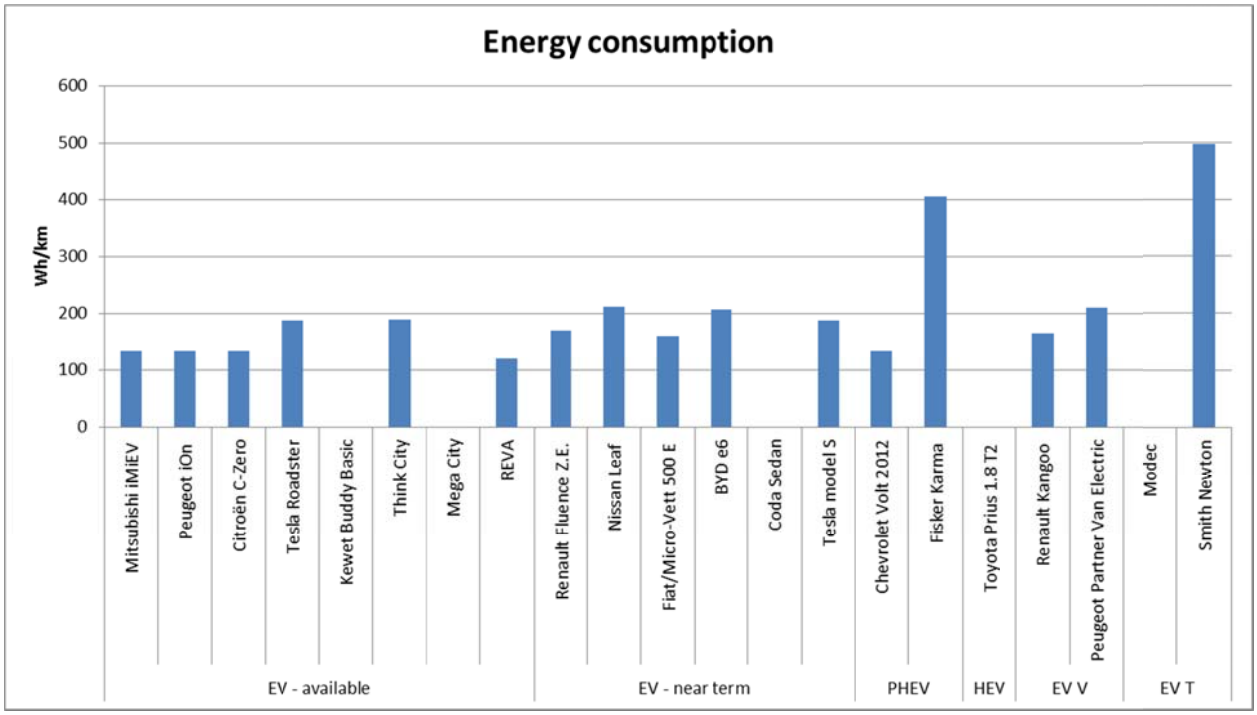

Figure 10: Energy consumption for each model

The energy consumption for EVs is in general between 130 and 200 Wh/km with almost similar consumption between current and near term EVs. The Fisker Karma has an energy consumption of more than 400 Wh/km while also the high weight of the trucks requires more energy for driving.

7.7. Top speed

The top speed can be an important parameter if the driving pattern includes driving on highways etc.

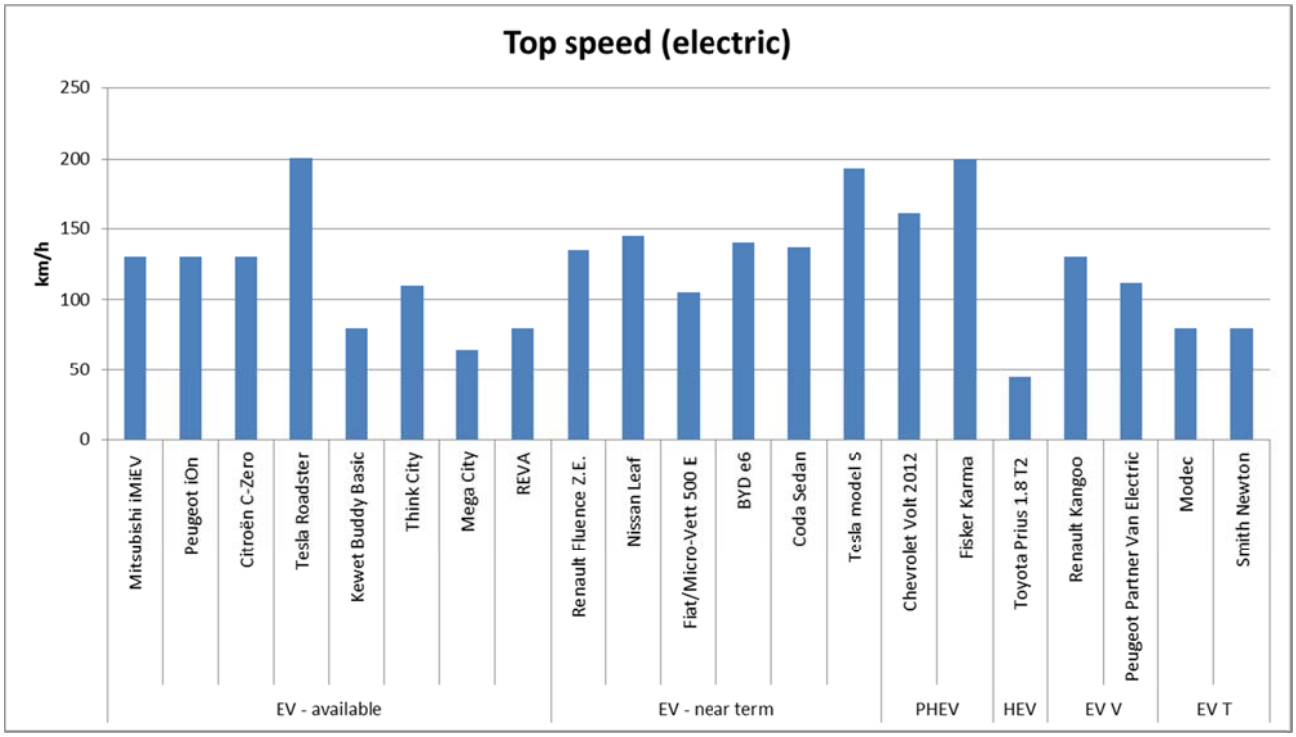

Figure 11: Electric top speed for the models

The electric top speed for EVs, both current and near term technology is in general between 100-150 km/h, with exception of the smaller urban cars and the sports cars. The top speed for these car types are respectively below 100 km/h for the urban cars and around 200 km/h for the sports cars. The vans and the trucks have a top speed around 80-120 km/h and may thereby not be ideal for driving on highways or following driving patterns that requires driving at high speeds.

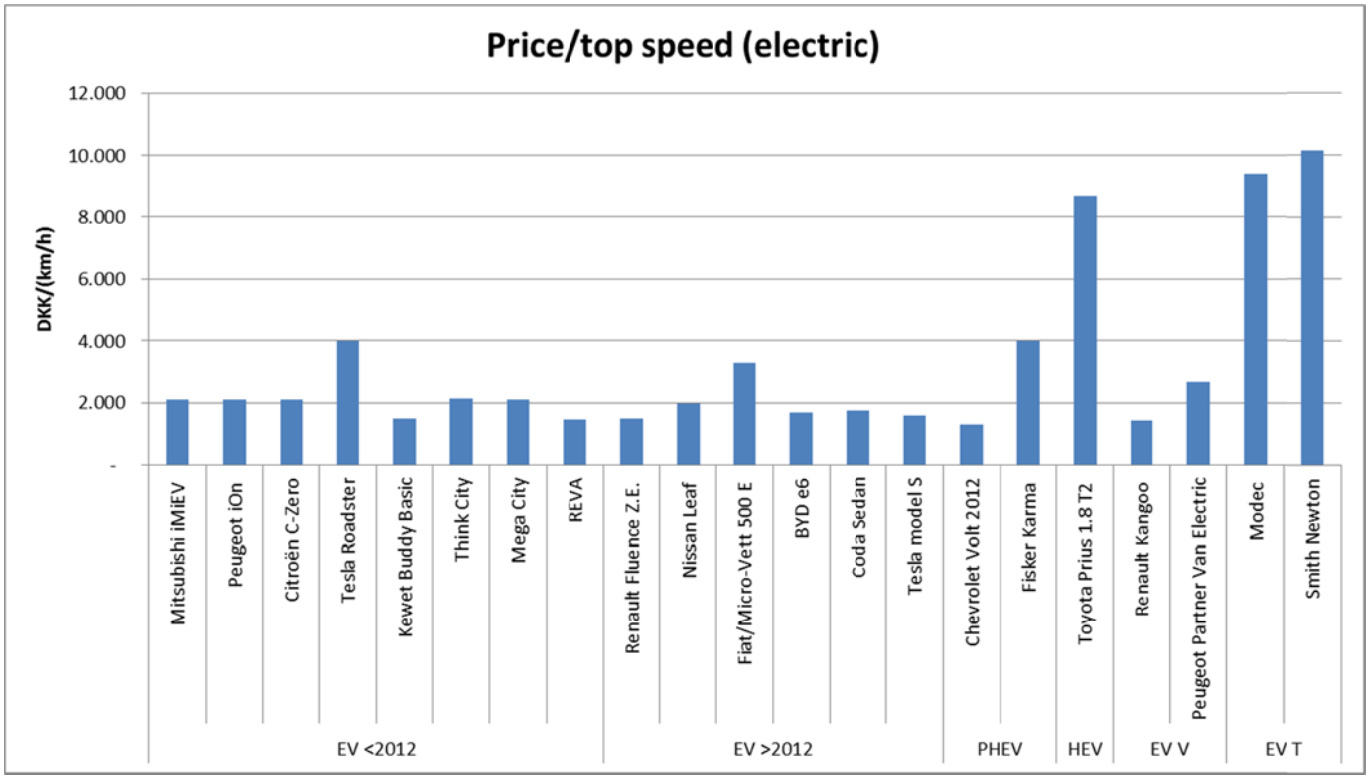

Figure 12: Top speed compared to investment costs

When including the investment costs most EV models have a cost around DKK 1,000-2,000 for every increase of one km/h. The vehicle types with the highest costs compared to top speed are the HEV and the trucks, which may be a result of the low electric top speed for the HEV and the high investment cost for the trucks.

8. References

Danish Transport Authority (2010) *Redegørelse - elbiler og plug-in hybridbiler (Report - electric vehicles and plug-in hybrid vehicles)*, Trafikstyrelsen - Center for grøn transport (Danish Transport Authority - Center for green transport).

ElFORSK, Power Circle and Test Site Sweden (2010) *Förslag till Nationellt Program för Utvärdering av Elfordon och Laddningsinfrastruktur - En förstudie rörande test och demomiljöer för elfordon i Sverige (Proposal for a national program for evaluation of electric vehicles and charging infrastructure - a preliminary study regarding the test and demonstration environments for electric vehicles in Sweden)*.

Frederiksberg Municipality (2011) 'Summary: Drifts- og forsyningsudvalget, 09-05-2011 (Operation and utility committee)', [online], available: http://www.frederiksberg.dk/PolitikOgDemokrati/DagsordenerOgReferater/Drifts-OgForsyningsudvalget/09-05-2011/b2dca852-f6bb-4cf8-bb80-bd72873c5d0e/0d6ead34-8fda-44f3-b5a4-8ea67e58f714.aspx [accessed

Stockholm Municipality and Vattenfall AB (2011) 'Elbilsupphandling', [online], available: http://www.elbilsupphandling.se/ [accessed